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Evolutive unification in composite Active Galactic Nuclei

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ABSTRACT

In this paper we explore an evolutionary Unified scenario involving super massive black hole (SMBH) and starburst (SB) with outflow, that seems capable of explaining most of the observational properties –of at least part– of AGNs

Our suggestion is explored inside the expectations of the Starburst model close associated with the AGN where the narrow line region (NLR), broad line region (BLR) and broad absorption line (BAL) region are produced in part by the outflow process with shells and in compact supernova remnants (cSNR).

The outflow process in BAL QSOs with extreme IR and Fe II emission is studied. In addition, the Fe II Problem regarding the BLR of active galactic nuclei (AGN) is analysed. Neither the correlations between the BAL, IR emission, Fe II intensity and the intrinsic properties of the AGN are clearly understood. We suggest here that the behaviour of the BAL, IR and Fe II emission in AGNs can be understood inside an **evolutionary and composite** model for AGNs.

In our model, strong BAL systems and Fe II emission are present (and intense) in young IR objects. Parameters like BALs, IR emission, Fe II/Hβ intensity ratio, Fe II equivalent width, broad lines line width, [O III]λ5007 Å intensity and width, narrow line region (NLR) size, X-Ray spectral slope in radio quiet AGN plus lobe separation, and lobe to core intensity ratio in radio loud AGN are proposed to be fundamentally time dependent variables. Orientation/obscuration effects take the role of a second parameter providing the segregation between Sy1/Sy2 and BLRG/NLRG.

Key words: galaxies: evolution – quasars: absorption lines – ISM: bubble – galaxies: starburst – galaxies: interaction

1 INTRODUCTION

Recent work: (i) has *provided* strong evidence for SMBH in the centres of most/all massive bulges; (ii) has *proved* the presence of massive SB in the central regions of a substantial fraction of AGN [both radio quiet (RQ) and radio loud (RL)].

From 3D and 1D Spectroscopic studies we have found kinematical and morphological evidence of a close relation between the AGN and extreme starburst, in nearby "BAL + IR + Fe II QSOs and mergers" (Lípari et al. 2005a,b,c,d, 2004a,b,c,d, 2003, 2000, 1994, Lípari 1994).

In particular, some of the results obtained for *nearby BAL QSOs*, such as strong IR and Fe II emission, strong blue asymmetry/OF in Hα, radio quietness, and very weak [O III]λ5007 emission (Low et al. 1989; Boroson & Meyers 1992; Lípari et al. 1993, 1994, 2003, 2005a; Lípari 1994; Turnshek et al. 1997), can be explained in the framework of the starburst + AGN scenario. In our study of Mrk 231 and IRAS 0759+6559 (the nearest extreme BAL + IR + GW + Fe II QSOs), we detected typical characteristics of young-starburst QSOs. In our evolutive model for young and composite IR QSOs (see for references Lípari 1994; Lípari et al. 2005a) it is suggested that some BAL system plus IR and Fe II emission could be linked to violent super massive–starburst + AGN which can lead to a large-scale expanding super giant shells, often obscured by dust. Several articles suggested that this evolutive model shows a good agreement with the observations (see Egami et al. 1996; Canalizo & Stockton 1997; Lawrence et al. 1997; Canalizo et al. 1998).

In this paper we explore an evolutionary Unified scenario involving both SMBH and SB with OF, that seems capable of explaining most of the observational properties –of at least part– of AGNs

1.1 Static Unification Model for AGNs

The so-called AGN unified models represent an attempt to explain the variety of sub-types as due solely to differences in the orientation of the central object and/or its nearby environment. There are two branches of unification, the radio-quiet and the radio-loud.

The radio-quiet unification interprets type 2 nuclei, i.e. those dominated by narrow emission lines, as normal nuclei or QSOs whose central regions, containing the ionising source and the surrounding Broad Line Region (BLR), are obscured by an edge-on opaque dusty torus. The observed narrow emission lines are produced at large distances from the nucleus and result from the ISM being photoinized by the nuclear UV radiation leaking trough the poles of the dusty torus. Reflection of the nuclear light by electrons and/or dust in the extra nuclear regions provides in some cases a periscopic view into the hidden active nucleus. In this scenario, normal type 1 nuclei are those seen directly without obstruction by the dusty torus.

Support for this scenario comes from the discovery of broad permitted lines in the polarized spectra of nearby type 2's, strengthening the idea that Seyfert 2's harbour obscured BLR's (e.g., Antonucci & Miller 1985; Lawrence 1987, 1991; Antonucci 1993; Miller & Goodrich 1990). Moreover 'ionization cones' have been found in several nearby AGNs (e.g., Wilson, Ward & Haniff 1988; Pogge 1988a,b; Tadhunter & Tsvetanov 1989; Storchi-Bergmann, Wilson & Baldwin 1992). These cones are generally aligned with the radio axis and perpendicular to the polarization vector (Antonucci 1993). These findings agree with the unified model, which predicts that only gas within a biconic region (defined by the opening angle of the obscuring torus) directly 'sees' the nuclear ionizing continuum, whereas the observer's line of sight to the nucleus is blocked and only a fraction of the central source's continuum is actually scattered towards him/her. Elvis & Lawrence (1988) found that NGC 1068 has a hard X-ray spectrum typical of a Seyfert 1, with very little X-ray absorption. They concluded that these findings are consistent with all the observed X-rays coming from reflection of the hidden Seyfert 1 spectrum by electrons in a photoionized region, extending the reflection model to the X-ray band (see however Wilson et al. 1992).

There are at least two or three main problems with this simple unification scenario,

(i) It does not explain the origin of the strong UV/blue continuum observed in most type 2 and their low polarization (Cid-Fernandes & Terlevich 1995). Cid-Fernandes & Terlevich suggested that active star formation close to the nucleus will explain this points plus the large strength observed in the near IR stellar lines of the nuclear spectra (Terlevich, Diaz & Terlevich 1990). The presence of young stars in the nuclear region of type 2 Seyferts has been confirmed by the detection of absorption lines from massive star in the UV (Heckman et al. 1995) and IR (Oliva et al. 1995).

(ii) There is a strong possibility that some type 2's are not obscured type 1's. Several low luminosity AGN are known to have undergone type transitions from type 1 to type 2 and/or vice-versa (see Aretxaga & Terlevich 1994 for a compilation of cases). Such nuclei are clearly not obscured type 1s. This fact indicates that short term evolution is playing an important role at least in some low luminosity AGNs.

(iii) Only few high-luminosity type 2 are known with $M_B < -23$ (Osterbrock 1993).

In the radio loud unification core dominated radio sources, i.e. BLRG and quasars, are systems with pole-on toroids and thus viewed approximately along the axis of the radio jet with the most extreme cases, i.e. those where the jet points roughly in the observers direction, showing superluminal motions in the inner parts of the jet. Lobe dominated radio galaxies, NLRG, are those systems where the torus is almost edge-on and the jet is close to the plane of the sky. There is again convincing evidence for the geometrical unification. The R parameter that measures the core to lobe intensity ratio is related to the FWHM of the Balmer lines. Lobe dominated radio sources (small R) tend to have broad Balmer lines while core dominated ones (large R) show only relatively narrow Balmer lines.

In all, the simple UM represents a step forward towards the unification of radio loud AGN. But there are some problems summarized by Gopal-Krishna, Kulkarni & Wiita (1996), namely the crisis of the relative sizes of radio galaxies and quasars, the apparent increase of the torus aperture with AGN luminosity.

In addition to the above problems with the simple unified model (UM), there are other that affect both the RQ and RL AGN. These problems are related to the observed behaviour of the permitted optical Fe II emission. The Fe II emission was first identified in 1966 (Wampler & Oke 1967) in the spectrum of 3C 273. Pioneering work by Steiner (1981) indicated the importance of Fe II emission in AGN and suggested a classification scheme based on the strength of Fe II. Boroson & Oke (1984) and Boroson, Persson & Oke (1985) studied the nebulosity around high luminosity quasars and found a clear segregation two groups according to the intensity of the NLR, the strength of Fe II, radio morphology and spectral index and Balmer line width. During the last decade considerable effort has been devoted to understand the origin of Fe II optical emission observed in many Seyfert 1 and QSOs. Extreme Fe II emission is not reproduced by standard photoionization models which cannot even account for the observed Fe II 4570 Å/Hβ line intensity ratios that is typically >6 but as large as 30 in some extreme emitters. This apparent failure of the standard photoionization model has lead to the search of correlations between Fe II intensity and other AGN properties.

There is further information apart from the optical and radio properties that show tantalizing and unexplained trends between observables. A correlation between the slope of the X-ray spectrum and the equivalent width of the Fe II λ 4570 Å emission was found for samples of QSOs (Wilkes & Elvis 1987) indicating that strong Fe II emitters are the AGNs with the softest X-ray spectrum. This is very puzzling because if, as suggested by some authors, the strong Fe II emission is produced by the presence of zones of the BLR of very high opacity to ionizing radiation, thus penetrated only by very hard X-rays, the opposite correlation should be found. Also puzzling, is that the most extreme Fe II emitters are radio-quiet quasars; contrary to what would be expected if the jets responsible for producing compact radio sources, are also to produce the strong Fe II emission.

But perhaps the most intriguing discovery is the strong anti-correlation found by Boroson & Green (1992) between

the Fe II 4570 Å/Hβ line ratio and the peak intensity of [O III] 5007 Å. Strong Fe II emitters have weak or absent [O III] while weak Fe II emitters have the strongest [O III] emission. Because the [O III] should be practically orientation-independent this anti-correlation is an indication that the nucleus of these galaxies are not seen along a preferred line of sight (i.e., this relation can not be explained by orientation effects). Furthermore, using only geometrical/orientation based arguments is very difficult to explain the large dynamical range observed in the [O III]λ5007/Hβ ratio. This ratio ranges from values larger than 20 in type 1 objects with weak or absent Fe II emission to essentially no detection of [O III]λ5007 in nuclei with strong Fe II emission.

Boroson (2002) extends the sample to include radio-loud AGN. His analysis shows a clear separation in the plane PC1-PC2 between radio loud and radio quit. His proposal is that BH mass and ANG luminosity are the key distinctions between the different class of objects.

1.2 Evolutive Unification Model for AGNs

Some connection between galaxy/star formation and nuclear activity has been suggested by several researchers (among others: Terlevich & Melnik 1985, Perry & Dyson 1985, 1992; Norman & Scoville 1988; Terlevich & Boyle 1993). Several works in the QSO luminosity function tend to underline the possible close relation between nuclear starbursts and AGN (e.g., Terlevich & Boyle 1993; Hoehnelt & Rees 1993). In luminous IR mergers and IR QSOs we proposed a composite scenario for the origin of the BAL and IR + Fe II emission (see for details Lipari et al. 2005a, 2003, 1994, 1993; Lipari 1994; Lipari & Macchetto 1992; Sanders et al. 1995, 1988a,b; Joseph & Wright 1985).

We propose a scenario where a SMBH is formed during the formation of the galactic core and an AGN powered by accretion. Which is formed by the interaction between a nuclear SB and the SMBH. The evolution of the SB generates a diversity of intrinsic properties that when combined extrinsic ones such a the orientation, are able to explain most of the observed differences between the different types of AGN

It seems that the problems of the static UM derive from the fact that it is static i.e. does not consider the evolution of the AGN itself on time scales less than 10^8yr. We propose that intrinsic parameters like the angular size of radio sources and their radio luminosity, the BLR spectrum (emission line width, Fe II intensity, etc), the NLR spectrum, NLR size and NLR luminosity, all depend on the evolutionary age of the AGN, while the observed parameters depend on age and also on the orientation of the AGN and its environment with respect to the observer.

The timescale for the development of megapersec size radio sources is similar to the lifetime of the AGN (Fanti et al. 1995). The age or lifetime of the AGN should also play an important role (Gopal-Krishna et al. 1996).

We propose a bi-parametric **evolutionary** model for AGNs. Intrinsic parameters like the BAL, Fe II intensity and BLR spectrum, NLR size and luminosity and radio luminosity, size and morphology, all evolve with a time scale of less than 10^8 yr. Young AGN are obscured BAL and strong Fe II emitters with relatively narrow line BLR and a compact and faint NLR; their radio emission is also compact. Old AGN are weak Fe II emitters with broad line BLR and extended and bright NLR and fully developed radio lobes. The orientation of the AGN/toroid takes the role of a second parameter providing the segregation between type 1/type 2, and BLRG/NLRG.

Radio emission comes later in the evolution, after the action of the winds from the SB have removed the ISM towards the regions of larger density gradient in the circumnuclear ISM distribution. Also the SB ejecta action may help in regularize and order the central magnetic field. Those systems were the spin of the SMBH points in the direction of the SB ejecta are the ones with higher probability of becoming powerful radio sources.

2 THE EVOLUTION FROM MERGERS TO QSOS

2.1 Evolutive links between IR Mergers and IR QSOs, with outflow

The luminosities and space densities of luminous IR galaxies (LIRGs; $L_{IR} > 10^{11} L_\odot$) in the local Universe are similar to those of quasi-stellar objects (QSOs; Soifer, Houck & Neugebauer 1987). In addition, at the highest IR luminosities, the presence of AGNs (and mergers) in LIRGs becomes important. Thus LIRGs probably represent an important stage in the formation of QSOs and elliptical galaxies. These results strongly suggest that it is important to perform detailed studies of possible links among mergers, LIRGs, QSOs and elliptical galaxies (see for references Lípari et al. 2005a)

In addition, the detection of a correlation between the mass of galactic bulges and the mass of supermasive black hole is a confirmation that the formation and evolution of galaxies (bulges/ellipticals, mergers) and super massive black hole (AGNs and QSOs) are physically related to one another (Magorrian et al. 1998; Ferrarese & Merrit 2000; Gebhardt et al. 2000; Kormendy 2000; Merrit & Ferrarese 2001; Kormendy & Richstone 1995).

In the last years, several possible *links* between *mergers, starbursts, IR QSOs and ellipticals* have been proposed. Specifically, Joseph et al., Sanders et al. and Lípari et al. suggested three complementary sequences and evolutive–links:

(i) merger → giant shocks → super-starbursts + galactic winds → elliptical galaxies;

(ii) merger → H_2-inflow (starbursts) → cold ULIRGs → warm ULIRGs + QSOs;

(iii) merger/**s** → extreme starburst + galactic-wind (inflow + outflow) → IR + Fe II + BAL composite/transition QSOs → standard QSOs and ellipticals → ? (galaxy remnants).

In this sequence a main step is not -yet- explored/studied. Which is the end phases of the evolution of the host galaxies + QSOs. Recently, we started theoretical studies (Lípari & Terlevich 2006, in preparation) for one of the more simple case: the end phase of elliptical galaxies. In particular, for this type of galaxy we are studying the processes when: the amount of gas is very low, and the star formation and SN events are almost finished. At this stage we can observe mainly stars+SN remnants and SMBH, which are very compact and dark objects.

2.2 The Evolution in the IR colour–colour diagram of mergers and QSOs (with outflow/BALs)

The IRAS colour-colour diagrams have been used as an important tool to detect and discriminate different types of activity in the nuclear/circumnuclear regions of galaxies. Lípari (1994) already found that the IR colours (i.e., IR energy distribution) of ∼10 extreme IR + Fe II QSOs are distributed between the power law (PL) and the black-body (BB) regions: i.e., the *transition area*. On the other hand, the low and moderate IR–Fe II emitters are located mainly in the PL region. In particular, we detected that Mrk 231 and IRAS 07598+6508 (the nearest IR + GW/OF + Fe II + BAL QSOs) have a close position in this diagram: near to the BB area; thus showing both systems strong starburst components. Recently, Canalizo & Stockton (2001) confirmed that the host galaxies of both QSOs have strong starburst populations (using Keck spectroscopy).

It is important to remark that of a total of ∼10 IR transition objects of this original sample, the first 4 systems are BAL IR QSOs. Therefore, we already suggested that BALs IR QSOs (like Mrk 231, IRAS 07598+6508, IRAS 17002+5153 and IRAS 14026+4341) could be associated with the *young phase of the QSO activity*.

Very recently, using our data base of more than 50 IR Mergers and QSOs with galactic winds and using for comparison the large sample of standard PG QSO (from Boroson & Green 1992) we have expanded our previous study. Figure 1 (adapted from Lípari et al. 2005a: their Fig. 15) show the IR energy distribution [spectral indexes $\alpha(60, 25)$ vs. $\alpha(100, 60)$; where $\alpha(\lambda2, \lambda1)$ = –log[F(λ2)/F(λ1)]/log[λ2/λ1]] for: (i) IR mergers and IR QSO with GW (originally 51 IR systems); (ii) standard QSOs from the PG QSOs sample of Boroson & Green (1992; originally 87 PG QSOs that have $z \leq$0.5).

IR fluxes–densities, in the bands of 12, 25, 60 and 100 μm, were obtained from the IRAS and ISO Archival Catalogue (using NED). Only objects with a good detection in the three required bands have been included. Also, the localisation of the three main regions in this colour-colour diagram (i.e., the QSOs/Seyferts, Starbursts, and powerful IR galaxies areas) have been plotted. An inspection of this diagram clearly shows the following:

(i) All the IR mergers with low velocity OF (LVOF) are located very close to the BB and starburst area.

(ii) Almost all the IR QSOs with extreme velocity OF (EVOF) are located in the transition region.

(iii) The standard QSOs and radio QSOs are located around the PL region.

(iv) All the BAL IR QSOs are located in the transition region, in almost a clear sequence: from Mrk 231 (close to the BB area) → IRAS 07598+6508 → IRAS04505–2958 → IRAS 21219-1757 → IRAS/PG 17072+5153 and IRAS 14026+4341 (close to the PL area) → standard QSOs.

These results first confirm our previous finding (obtained from a small sample of IR galaxies): in the sense that *IR QSOs are probably "young, composite and transition" objects* (between IR mergers and standard QSOs). Furthermore, in this IR colours diagram a main evolutive parameter is the values of the OF: from mergers with LVOFs to OSOs with EVOFs.

3 THE YOUNG AND COMPOSITE NATURE OF BALS + IR + FE II MERGERS/QSOS

3.1 The BAL Phenomenon

In the last decades, the nature of the BAL phenomenon and its relation to the overall quasar population has been the subject of debate (see for references Lewis, Chapman & Zuncic 2003). Two main interpretation for the occurrence of BALs are proposed: the orientation and evolution hypothesis. According to the orientation interpretation "all QSOs" possess BAL OF, so that the frequency of detection only translate to the rate at which our line of sight intercept the OF (Weyman et al. 1991). According to the evolution hypothesis the rate of the BAL phenomenon is interpreted as a particular phase of the QSO's life (Lípari 1994; Voit, Weymann & Korista 1993).

Observational evidence supporting the orientation hypothesis come from spectral comparison of BAL and non-BAL QSOs (Weyman et al. 1991) and polarization studies (Hines & Will 1995; Goodrich & Miller 1995; Schmidt & Hines 1999).

Evidence in favour of the evolution hypothesis comes largely from the high number of BALs detection in IR + Fe II QSOs/mergers (see for references Lípari et al. 2005a, 2003, 1994; Lípari 1994; Boroson & Meyer 1992; Low et al. 1988, 1989). Further support for the evolution hypothesis has been provided for radio observations of BAL QSOs, which are inconsistent with *only orientation schemes* (Becker et al. 2000, 1997).

In the last decade, we proposed and evolutive scenario for BAL + IR + Fe II QSOs, where mergers fuel extreme star formation processes and AGNs, resulting in strong dust and IR emission, large number of SN and Hyper Nova events with expanding super giant bubbles and shell. The BALs in IR + Fe II QSOs were associated with this composite nature of these systems (Lípari et al. 2005a; Lípari 1994).

3.2 BALs in IR + GW + Fe II mergers/QSOs

In general, the role of BALs in IR+GW/OF+Fe II QSOs/mergers must be carefully considered, since: (i) Low et al. (1989) and Boroson & Meyers (1992) found that IR selected QSOs show a 27% low-ionization BAL QSO fraction compared with 1.4% for the optically selected high-redshift QSOs sample (Weymann et al. 1991); (ii) extreme IR galaxies (ULIRGs) are mainly mergers (see Section 1); (iii) recently Maiolino et al. (2003) reported also a high fraction of BAL QSOs at very high redshift (z ∼6). The high percent of occurrence of broad absorption in extreme IR + GW/OF + Fe II QSOs/mergers may be signals a fundamental relation (rather than merely a coincidence).

Lípari et al. (1993, 1994, 2003, 2004a,d, 2005a); Scoville & Norman (1995); Perry 1992; Perry & Dyson 1992; Dyson et al. 1992; Egami et al. (1996); Lawrence et al. (1997) and others proposed that the extreme BAL + IR + GW/OF + Fe II phenomena are related –at least in part– to the *end*

phase of an "extreme–starburst + AGN" and the associated powerful bubble/galactic–wind. At the final stage of a strong starburst, i.e., type II SN phase ([8-60] $\times 10^6$ yr from the initial burst; Terlevich et al. 1992; Norman & Ikeuchi 1989; Suchkov et al. 1994) giant galactic arcs and extreme Fe II+BAL systems can appear.

Recently, a new method for decoupling the spectra of the QSO/AGN from the host galaxy –using 3D spectroscopy– was developed (Sanchez et al. 2004). Using this new method for the very deep Gemini GMOS 3D spectroscopic data of the nearest BAL + IR + Fe II QSO Mrk 231, we have obtained the clean spectra of the QSO and the host galaxy for the nuclear region (r $\sim 2''$). From this study, the following main result was found: in the pure host galaxy spectrum a strong nuclear starburst component was clearly observed (for the first time, at optical wavelength), mainly as a very strong increase in the flux, at the blue region (Lipari et al. 2006). This result confirm the composite nature of the very nucleus of Mrk 231.

3.3 The new BAL + IR + Fe II QSO IRAS04505–2958 and the Composite hyper–wind model for the origin of BALs and Lyα blobs

It is important to remark that in the Fig. 1 IRAS 04505–2958 is located exactly in the sequence of BAL QSOs, between the positions of IRAS 07598+6508 and IRAS 21219-1757. This IR + GW + Fe II QSO shows probably the more interesting OF supershell/arc detected to date. Which is very extended (of $\sim$20–25 kpc) and it is located very far from the nucleus (at r $\sim$ 15 kpc; see for details their Fig. 16a). The UV HST FOS spectra –of IRAS 04505–2958– clearly show a BAL system at C IVλ1549 emission line (see Lípari et al. 2005a).

On the other hand, the ionizing radiation from the newly formed young stars should lead to prominent Lyα emission due to recombination of the hydrogen in the ISM. Thus, extended Lyα emission could be an important spectral signature of young systems, specially at high z.

In the last years very extended blobs -specially in Lyα- has been detected in a variety of high (and low) redshift objects: (i) Several recent surveys of Lyα emitters at high z (Steidel et al. 2000; Keel et al. 1999; Francis et al. 2001; Matsuda et al. 2004) have established the existence of extended, highly luminous Lyα halos (of 50-100 kpc and 1.4×10^{44} erg s^{-1}). Taniguchi & Shioya (2000) suggested a starburst hyper–wind scenario for the origin of the Lyα blobs. (ii) The results of the surveys –at high z– of bright Sub-mm source (Chapman et al. 2004a; Bower et al. 2004, Swinbank et al. 2005) suggest that a very high fraction (3/4) of these sources are extended and complex (i.e., showing extended and highly luminous Lyα halos; Chapman et al. 2004a). (iii) In the last decade, several extended Lyα halos/blobs were detected in high redshift radio sources (see for references Reuland et al. 2003). In particular, Reuland et al. (2003) and Dey et al. (1997) proposed that in high z radio source: starburst-super winds and radiation pressure from AGN can disrupt and stop the accretion process and to generate the extended Lyα nebulae/halos.

It is important to remark, that even in the more extended and studied blob: i.e. LAB1 in SSA 22 (Steidel et al. 2000) there are different interpretations, about their origin. In particular, Matsuda et al. (2004) proposed the presence of extended shells and arcs (in this blob/LAB1). They associated these shells/blob with a strong star formation process, which is in agreement with the starburst scenario for the hyper–wind model (proposed by Taniguchi & Shioya 2000). However, Chapman et al. (2004b) suggested that the multiwavelength data of LAB1 are consistent with an obscured AGN (as the source of the blob).

Very recently, Lípari et al. (2005a) proposed a *composite hyper–wind scenario* in order to explain the very extended blob/shell (of 30 kpc) found in the new BAL QSO IRAS04505-2958 (this BAL IR-QSO was discovered using the IR colour-colour diagram: Fig. 15 in Lípari et al. 2005a). In addition, they suggested that extreme explosions and extreme starbursts are associated mainly with the interaction between: the QSO and the nuclear star formation process.

At high redshift (z > 2.0), we are studying deep 3D spectroscopic data of Sub-mm and Radio BAL-QSOs, using Gemini+GMOS and ESO VLT+VIMOS. It is important to remark, that the link between our two programs –at high and low z– is not only about some individual IR BAL-QSOs, since luminous Sub-mm source at high z imply –in the rest-frame– luminous IR sources. Thus, probably we are studying the same type of objects and similar physical processes (in both programs).

In addition, Lípari et al. (2004a, 2003) found that 75% of IR QSOs/mergers (including BAL QSOs) show clear evidence of OF. Some of these OFs generate super giant galactic bubbles, and for the case of NGC5514 the 3D spectroscopy maps show that the bubble was detected just in the rupture and preblowout phase. It is interesting to note that the same percent: of 75% was found by Chapman et al. (2004b) in their study of Sub-mm sources showing extended and highly luminous Lyα halos (the Sub-mm sources are the high-z –or redshifted– version of luminous IR galaxies).

Therefore, extreme OF associated with jets and giant explosions/ hypernovae could generate extreme galactic-winds that produce expanding shells, which could generate BAL systems and extended blobs or halos (Lípari et al. 2005a,b,c,d, 2003; Punsly & Lípari 2005; Reuland et al. 2003; Lípari 1994).

3.4 3D spectroscopy of Mrk 231: the nearest BAL + IR + Fe II QSO

Very recently, we found for Mark 231 that the BAL I system could be associated with bipolar outflow generated by the weak/sub-relativistic jet; and the BAL III system with a supergiant explosive events (Lípari et al. 2005a; Punsly & Lípari 2005).

The variability of the short lived BAL–III Na ID system was studied, covering almost all the period in which this system appeared (between $\sim$1984–2004). We found that the BAL-III light curve (LC) is very similar to the shape of a SN LC. The origin of this BAL-III system was discussed, mainly in the frame work of an extreme explosive event.

The HST images of Mrk 231 show 4 (or possibly 5) nuclear superbubbles or shells with radius r $\sim$ 2.9, 1.5, 1.0, 0.6 and 0.2 kpc. For these bubbles, the 3D Hα velocity field (VF) map and 3D spectra show in the 3 more external bubbles (S1, S2, S3), multiple emission line components with OF velocities, of $\langle V_{\rm OFBubble} \rangle$ S1, S2 and S3

$= [-(650-420) \pm 30], [-500 \pm 30]$, and $[-230 \pm 30]\,\mathrm{km\,s^{-1}}$. We suggest that these giant bubbles are associated with the large scale nuclear OF component, which is generated –at least in part– by the extreme nuclear starburst: giant-SN/hypernova explosions.

3.5 The relation between BAL + IR + Fe II young QSOs and very high redshift BAL QSOs

It has been proposed that extreme starburst + galactic wind processes associated with IR mergers could play a relevant role in the formation and evolution of galaxies and QSOs/AGNs, i.e. in their structure, kinematics, metallicity, etc. Furthermore, recent detailed observations and theoretical studies have confirmed that OF, galactic winds, BAL, large amount of gas+dust and strong Fe II emission are important components and processes at high redshift ($z \sim$ 4–6), when the galaxies and QSOs formed (Frye, Broadhurst, & Benitez 2002; Ajiki et al. 2002; Pettini et al. 2001; Dawson et al. 2002; Carilli et al. 2004a,b; Solomon et al. 2003; Taniguchi & Sioya 2000; Barth et al. 2003; Iwamuro et al. 2002; Freudling, Corbin, & Korista 2003; Maiolino et al. 2004a,b).

On the other hand, Maiolino et al. (2004a,b, 2003) presented near-IR spectra of eight of the more distant QSO (at $4.9 < z < 6.4$). Half of these QSOs are characterised by strong UV BAL systems (at C IV, Mg II, Si IV, Al III lines). Although the sample is small, the large fraction of BAL QSOs suggest that the accretion of gas, the amount of dust and the presence of OF process are larger (in these objects) than in standard QSO at $z < 4.0$. They also suggested that the very high amount of dust was generated by early explosions of SNe (Maiolino et al. 2004b).

Finally, it is important to remark the similar properties found in IR + GW/OF + Fe II + BAL QSOs at low redshift and very high redshift BAL QSOs (at $z \sim 6.0$; Maiolino et al. 2003, 2004a,b; Carilli et al. 2004a,b). According to these similarities, we proposed that the *phase of young QSO* could be associated with the following main processes: (i) In young QSOs with extremely large amount of gas (concentrate in their nuclear region). The accretion rate of gas –by the SMBH– could be extremely high (see Maiolino et al. 2004a). (ii) In addition this extremely large amount of molecular gas could generate extreme starbursts; and the presence of AGNs could increase the SF close to the nucleus. Specially in the accretion disks, with properties –of the SF– similar to the population III of stars. In these extreme starbursts –close associated with QSOs/AGNs– it is expected giant SN or HyN explosions. (iii) In young and distant QSOs the very high number of BAL detections suggest that composite OFs (or EVOFs) play a main role in their evolution.

4 THE FE II PROBLEM AND THE FE II CORRELATIONS

The optical spectrum of many AGN is dominated by two broad permitted Fe II emission line blends, one centred at about 4570Å(Fe II 4570) the other centred at 5350 Å. Optical Fe II has now been measured in the spectrum of several hundred broad line AGN, showing a large range of intensity relative to Balmer recombination lines.

From the theoretical point of view, considerable efforts have been devoted to understand the origin of Fe II optical emission in broad line AGN during the last decades. However, extreme Fe II emission is not well explained by standard photoionization models which cannot account for Fe II 4570 A/Hβ line intensity ratios larger than 6 (but it goes from 0 to 30). The origin of this range of values remains unexplained.

The source of heating for the Fe II emitting gas could be associated with:

- Zones of the Broad Line Region of very high opacity to ionizing radiation, thus penetrated only by very hard X–rays (Kwan & Krolik 1981)
- Jets responsible for the compact radio source (Norman & Miley 1984). However, it should be noted that the most extreme Fe II emitters are radio–quiet quasars while Fe II is not detected in many radio loud AGN.
- Nuclear starburst where violent star formation processes occur in high metallicity/pressure environments (Terlevich & Melnick 1988).
- Collisional ionization process (Joly 1987, 1993; Veron et al. 2006), which could be related mainly with shocks, in out flow events.

In order to learn about the main factors controlling the optical Fe II emission, relations have been searched between the optical Fe II equivalent width –or Fe II relative intensity– and AGN parameters. In recent years, there were many reported correlations involving the Fe II emission. Some of them seem to be fundamental to AGNs (Steiner 1981, Boroson & Green 1992). The following are some of the most important relations and the associated interpretations reported for Fe II emitters,

(i) Among the Fe II relations the most important one is probably the anti-correlation between (Fe IIλ4570 / Hβ) and I([O III]λ5007 / Hβ) emission line ratios found by Boroson & Green (1992) This anti-correlation represents the first eigenvector in the principal component analysis of a sample of more than 100 QSOs with high S/N spectroscopy, indicating that represents a fundamental relation. This unexpected result links the properties of the BLR with those of the NLR. Why [O III]λ5007 / Hβ (and in general all forbidden lines) should be weak or even absent in strong Fe II emitters or why AGN with strong forbidden lines have no detectable Fe II emission? Because the [O III] should be practically orientation-independent this anti-correlation is an indication that the nucleus of these galaxies are not seen along a preferred line of sight (i.e., this relation can not be explained by orientation effects). Furthermore, using only geometrical/orientation based arguments is very difficult to explain the large dynamical range observed in the [O III]λ5007/Hβ ratio. This ratio ranges from values larger than 20 in type 1 objects with weak or absent Fe II emission to essentially no detection of [O III]λ5007 in nuclei with strong Fe II emission.

(ii) An anti-correlation between I(Fe II λ4570) or I(Fe II λ4570/Hβ) and FHWM(Hβ) has been observed (Boroson et al. 1985). Zheng & O'Brien (1990) claim that this anti-correlation prove that the Fe II emission is more aspect dependent than Hβ or the underlying continuum. However,

Boroson & Green (1992) find similar line widths for Fe II and Balmer emission in the Palomar-Green QSO sample making very difficult to support a geometry in which they do not originate in the same region.

(iii) An anti-correlation between EW(Fe IIλ4570) and *soft* (0.2-3.5 keV) X-ray index has been observed (Wilkes & Elvis 1987). Boroson (1989) and Zheng & O'Brien (1990) refuted this relation, but Shastri et al. (1993) confirmed Wilkes & Elvis findings and explained the differences with Zheng & O'Brien (1990) mainly as a consequence of the relation being significant in radio quiet AGN only. A related correlation between (Fe IIλ4570 /Hβ) and *soft* (0.2-3.5 keV) X-ray index has been confirmed by Laor et al. (1994) recent study of the X ray properties of a subset of bright Palomar-Green QSO.

(iv) There is trend between IR luminosity and Fe II in the sense that IR luminous AGN with broad line emission have strong Fe II emission (see Low et al. 1988, 1989; Boroson & Mayer 1992). Lípari, Terlevich, & Macchetto (1993) found that almost 100 % of the AGN with extremely strong optical Fe II blends are ultra-luminous IR AGN.

A correlation between Fe II emission and the far-IR index α(25,60) has been reported by Keel et al. (1994); they noted that the correlations between Fe II and far-IR emission present a clear problem to unification models based in orientation effects (the far-IR luminosity should be almost orientation-independent).

(v) A trend has been suggested between (Fe IIλ4570 /Hβ) and R the ratio of the core to extended lobe radio fluxes. R is large in core dominated radio sources.

(vi) Boroson & Green (1992), found a marked dependence of the broad Hβ asymmetry with Fe II strength. Strong Fe II emitters tend to have blue asymmetric lines while weak Fe II is associated with red asymmetry in the form of a red wing extension.

Is not possible to interpret all of these correlations inside current unified models (Boroson 2002; Boroson & Green 1992; Laor et al. 1994; Joly 1993). Furthermore, since the discovery of AGN several models have been proposed to explain their observed line ratios (Shields et al. 1972; Netzer 1976; Krolik & McKee 1978; Kallman & Krolik 1986; Collin-Souffrin 1986; Collin-Souffrin & Dumont 1986; Ferland & Rees 1988). These models are quite successful in accounting for the narrow lines and many of the strongest broad lines but failed with the Fe II lines that in many AGN emit a substantial fraction of all the BLR energy. Current models predict a maximum Fe II intensity far below the observed average value (for a review see Joly 1993). Also the observed range in Fe II$_{TOT}$/Hβ is huge, it goes from essentially 0 up to about 30. The origin of this range in the ratio of two broad permitted lines also remains largely unexplained.

On the other hand, recent work has pointed towards a possible connection of AGN with strong Fe II emission with Starburst activity to explain at least part of the observed activity. The strong Fe II emitters representing the link between starbursts and classical or normal Fe II AGN (Lípari et al. 2005a, 2004d, 2003, 1994, 1993). The prominence of Fe II emission in quasars with strong infrared to optical luminosity ratio (Low et al. 1989) is consistent with the assumptions of a heating source linked to violent star formation processes (Terlevich & Melnick 1985) and of Fe II emission by rapidly cooling supernovae remnants occurring in the central regions of massive galaxies undergoing intense starburst activity (Terlevich et al. 1992). In the Starburst model for AGN the BLR is produced in compact SNR (cSNR) and the observed emission lines are the product of reprocessing of shock radiation by two high density thin shells and the ejecta (Terlevich et al. 1992). One important aspect of this model is the abundances of the ionized gas emitting the BLR lines are the abundances of the envelope of the star and the SN ejecta and not the abundances of the ISM. Given that the expectation is that the ejecta of massive SN type II is extremely metal rich with respect to the galaxy ISM, there is a good scope to produce strong metal emission lines particularly of Fe peak elements in the associated cSNR.

Boroson (2002) suggests that the physical parameter behind the RL/RQ segregation is the mass of the BH as evidenced by the Hβ FWHM difference between the groups. The fact that there is an anti correlation between [O III]FWHM and HβFWHM tend to suggest exactly the opposite. Whittle et al. have found that FWHM [O III] is a good indicator of the bulge velocity dispersion and therefore its mass. If the correlation between bulge mass and BH mass holds for this sample the fact that the mean FWHM [O III] in RQ is larger than in RL systems suggests that they are located in less massive bulges and therefore are powered by less massive BH.

It is important to remark that Lípari (1994) and Lawrence et al. (1997) already proposed that the nuclear OF is a main process/parameter, that could explain some of these correlations, observed in AGNs and QSOs. Furthermore, using our database of IR QSOs with gallactic winds and OF we found a correlation between the Fe IIλ4570/Hβ vs. velocity of OF (see Figure 2; which is adapted from Fig. 30 of Lipari et al. 2004d). We suggested that a probable explanation for the link between the extreme Fe II emission and the extreme velocity OF is that both are associated to the interaction of the star formation processes and the AGN, that generate extreme explosive/HyN events.

5 THE SPECTRAL EVOLUTION OF COMPOSITE AGNS WITH OUTFLOW (THEORETICAL RESULTS)

We propose to study the evolution on the interaction between a nuclear SB, the SMBH and the OF.

5.1 The evolution of NLR, associated with outflow/shells

If most of the energy from the stellar winds and SN explosions from the central star forming region is thermalized, a hot cavity in the interstellar medium (ISM) will be created. This hot "bubble" will expand and shock the cluster ISM. A region of constant high pressure will form inside the radius that contains all the SN (r$_{SN}$ Chevalier and Clegg 1985).

The bubble will expand faster along the steepest density gradient (i.e. along the poles in the case of a disk), creating an elongated hot cavity. The shocked ISM will cool in a time scale proportional to V_{shock} and form a thin dense shell. The cooling time is,

$t_{cool} \sim 2000 \frac{v_8}{n_3}$ yr

and cooling distance,

$r_{cool} \sim 2\frac{v_8^2}{n_3}$ yr

where $v_8 = V_{shock}/10^8$ cm s^{-1}, and the pre-shock density is $n_3 = n_{interstellar}/10^3$ cm^{-3}.

The thin shell in pressure equilibrium with the hot cavity will reach a density

$n_{sh} = \frac{P_0}{T_{sh}} = 10^8 k_{-1}^{-2} T_{sh,4}^{-1}$

where $T_{sh,4} = T_{sh}/10^4$K is the temperature of the thin shell. This fast expanding thin shell photo-ionized by the radiation from the core of the cluster will emit relatively broad, FWHM $\sim V_{sh} \sim 2000$ km s^{-1} forbidden and permitted lines. Among the forbidden lines stronger than Hβ are [O III]λ 4363, 5007, 4959, [OI]λ 6300.

The continuous energy input of the SN will make the bubble to expand until it reaches the edge of the cluster gas density distribution. At this point, the shock will accelerate and Rayleigh-Taylor instabilities will set up and break the dense shell. The hot thermal gas will escape between the fragments as a wind. The ionizing radiation will also escape and start to ionize the galactic ISM. Interaction of the out flowing wind with clouds orbiting the bulge can give rise to radial motions and some X-ray emission. The outfloing wind will accelerate the clouds. The terminal velocity reached by dense clouds (V_{cloud}) i.e. those where the wind can drive an isothermal shock will be,

$V_{cloud} \sim n_{cloud}^{1/2} V_{wind}$

where n_{cloud} is the density of the fragments and V_{wind} is the wind velocity (Franco et al 1993). High density clouds are not much affected by the wind while low density clouds and the ISM will be accelerated almost to half of the wind velocity.

After some time the wind will shock the galaxy ISM at large distances from the nucleus. The size of the shock driven by the wind into the galactic ISM is (Weaver et al. 1977, Chevalier & Clegg 1985),

$R_{wind} \sim 4\left(\frac{\nu_{sn}\epsilon_{51}t_7^3}{n}\right)^{1/5} Kpc$

More ionizing radiation will reach the galactic ISM as the fragmented shell expands and finally disperse. This will giving rise to optical filaments emitting narrow lines with line ratios typical of the NLR and line width corresponding to the velocity field of the ISM of the galaxy, i.e. 200 < FWHM < 1000 km s^{-1} depending mainly on the mass of the galaxy.

The observed line ratios, FWHM and size of the NLR will therefore evolve on time scales comparable to the time scale for the wind development. This time scale will depend on the rate of energy input size of the SN region and on the details of the gas distribution. There will be differences induced by the shape of the star forming region. Disk like regions of star formation will produce collimated winds while by contrast spheroidal regions will produce spherical winds.

Finally, it is important to remark that in the nearest BAL + IR + Fe II QSOs –Mrk 231– very deep 3D Gemini+GMOS spectroscopic data show the absence of the NLR (Lípari et al. 2006). We suggested that the multiple explosive events, detected previously in Mrk 231, could explain –at least in part– the absence of the NLR. In addition, a similar result was found in the other nearby BAL + IR + Fe II QSO: IRAS 07598+6508 (Veron et al. 2006).

5.2 The evolution of BLR, associated with multiple compact SN remnants

The composite QSO phase lasting from $\sim$ 8 Myr to $\sim$ 60 Myr is dominated by the type II SN activity and their remnants. The SNR of metal rich intermediate mass stars (M$\sim$ 8 to 25 M$\odot$) are presumably very luminous because their kinetic energy is rapidly thermalized by dense circumstellar material around the red supergiant progenitor evolving in the high pressure ISM of the star forming region. These compact remnants are probably the BLR of some AGNs.

Supernova remnants evolving in a dense and homogeneous CSM ($n > 10^5$ cm^{-3}) reach their maximum luminosity ($L > 10^7$ L$\odot$) at small radii ($R < 0.1$ pc), soon after the SN explosion ($t < 20$ yr) and while still expanding at velocities of more than 1000 km s^{-1} (Shull 1980; Wheeler et al. 1980; Draine and Woods 1991; Terlevich et al. 1992). In these compact SNRs, radiative cooling becomes important well before the thermalization of the ejecta is complete, making the remnant miss the Sedov track. As a result, the shocked matter undergoes a rapid condensation behind both the leading and the reverse shocks. Two concentric, high-density, fast-moving thin shells are then formed. The cool, dense shells, the freely expanding ejecta, and a section of the still dynamically unperturbed interstellar gas, are all irradiated and ionized by the photon field produced by the radiative shocks.

Terlevich et al. (1992) showed that the predicted line intensity ratios from the simple cSNR model are in good agreement with those observed in the BLR of AGN. In addition the model has the following properties in common with the BLR of AGN: Peak bolometric luminosity over 10^{43} ergs, emission line width of about 5000 km s^{-1}, BLR size of about $0.01pc$, two main broad line emitting regions, one with high density ($n_e \sim 10^{12}$ cm^{-3}) and low ionization (LIL), and the other of lower density ($n_e \sim 10^{10}$ cm^{-3}) and higher ionization (HIL), column density of ionized gas of about 10^{23} cm^{-2}, total mass of ionized gas in the BLR from about 1M$\odot$ to about 10M$\odot$, power-law ionizing spectrum of the form $f_\nu \propto \nu^{-0.5}$ up to $\sim 100kev$ with a bump between 10 eV and 400 eV, absence of broad forbidden lines, stable BLR emitting gas, small X-Ray absorption column density, redshift and line-width differences between HIL and LIL systems.

Terlevich et al. (1992, 1995) have analysed the time dependent process that occurs prior to thin shell formation in rapidly radiating cSNR during its maximum luminosity. They have found that an inherent delay between the photon emission and the time required to increase the density of the cooling gas, leads to a lag between the observed continuum burst and the emission lines response. This delay is intrinsic to the physical processes investigated and not related to the geometry of the system; there are in fact no light-crossing time arguments involved. The total width of the cold or photoionized region is only about 10^{13} cm (about 300 light seconds), yet, delays of up to several weeks between continuum and lines emission are generated.

The initial conditions for modelling cSNR in the work of Terlevich et al. (1992, 1995) were adequate for a low mass SN progenitor (M $\sim$ 7 M$\odot$) that represents the most common type II SN event. More massive progenitors will have different evolution involving slower shocks due to more mas-

sive ejecta. Also the ejecta composition may be very metal rich in massive type II SN. Due to the low sock velocity and the large metal content reverse shock cooling times will be very short and as a consequence the evolution of the reverse shock may dominate the radiative phase of these remnants.

In young stellar populations Fe is produced exclusively by massive (M> 12 M⊙) type II SN. SN type II with progenitors with initial masses below that limit produce basically no Fe (see Renzini et al. 1993). Theoretical models of nucleosynthesis in massive type II SN predicts the Fe/H ratio to be more than 10 and up to 30 times over-solar. Models also predict that only SN with progenitors more massive than 12M⊙ will produce Fe. This implies that during the evolution of a stellar cluster there will be a well defined epoch during which the ejecta from SN will be Fe rich. This corresponds to cluster ages between ∼ 8 Myr, the life-time of a 25M⊙ stars at the upper limit for the mass of a type II SN progenitor, and ∼ 20 Myr, the life time of a 12 M⊙ (interestingly this is the same age range than that of red-Supergiants).

During the evolution of a cluster in the SNII stage the turn off mass diminishes from ∼ 25 M⊙ to ∼ 7 M⊙. At the same time the mass of the SN ejecta will diminish from ∼ 20 M⊙ down to maybe ∼ 1 M⊙. If the energy per SN does not change with the mass of the progenitor, the ejecta of the most massive progenitors will be slower than that of the lower mass ones by $\sim 20^{1/2} \sim 4.5$ assuming energy conservation.

The slower ejecta will drive slower and cooler shocks. The emitted X-ray spectrum of massive cSNR is thus predicted to be deficient in hard X ray with respect to that of low mass normal cSNR. Terlevich et al. (1992) found a turnover in the emitted spectrum at around 20 to 40 kev. The simple scaling above would suggest that for massive cSNR the turnover should be around 1 kev . The estimate of the shape of the emitted x ray spectrum by a population of massive cSNR will have to wait detailed computations of the evolution of a massive cSNR.

Because of the slower reverse shocks and the much higher abundance the evolution of the reverse shock is expected to dominate the luminosity evolution of the remnant. In these conditions, the main sources of ionizing radiation would be the reverse shock while the reprocessing will be done by the ejecta and the reverse shock thin shell.

Therefore early in the evolution of a young cluster evolving in a high pressure environment, at a time when the turn-off mass is between 25 and 12 M⊙, the cSNR will emit relatively narrow broad lines with FWHM∼ 2000 km s^{-1}, strong Fe II lines and will be very deficient in hard X rays. Later in the evolution of the cluster, when the turn-off mass falls below 12 M⊙ the cSNR emits broader lines with FWHM∼ 5000km s^{-1}, weak or no Fe II lines and strong hard X rays.

6 COMPOSITE BAL PROCESSES, AND THE ROLE OF SUPERGIANT SHELLS AND HYPER NOVAE

In section 3.4, we already noted that for Mrk 231 were found evidence that the BAL I and III systems are probably associated with: the AGN sub relativistic jet and the nuclear SB with giant explosions and expanding shells, respectively (Lípari et al. 2005a; Punsly & Lípari 2005). Thus, it is important to study this type of composite BAL process/scenario.

In particular, the presence of multiple concentric expanding supergiant bubbles/shells (in Mrk 231), with centre in the nucleus and with highly symmetric circular shape could be associated mainly with giant symmetric explosive events (Lípari et al. 2005a,c,d). These giant explosive events could be explained in a composite scenario: where mainly the interaction between the starburst and the AGN could generate giant explosive events. In particular, Artymowicz, Lin, & Wampler (1993) and Collin & Zahn (1999) already analysed the evolution of the star formation (SF) close to super massive black hole (SMBH) and inside of accretion disks. They suggested that the condition of the SF close to the AGNs could be similar to those of the early/first SF events, where giant explosive processes are expected, generated by hypernovae (with very massive progenitors: M ∼100–200 $M_{\odot}$; see Heger & Woosley 2002; Heger et al. 2003, 2002). In accretion disk, the star–gas interactions can lead to a special mode of massive star formation. Furthermore, the residuals of the first SNe (neutron stars) can undergo a new accretion/interaction phase, with the gas, leading to very powerful SN or hypernova explosions.

Furthermore, an explosive scenario for the origin of the BAL III system (in Mrk 231) could explain: the shape of the light curve variability, and also the presence of multiple concentric expanding superbubbles/shells (Lípari et al. 2005a,c,d). Recently, one of the most important developments in the study of SNe is the discovery of some very energetic SNe, whose kinetic energy exceeds 10^{52} erg (called hypernovae, HyNe; Paczynsqui 1998; Wang 1999; Galama et al. 1999; Hjorth et al. 2003). In particular, these HyNe were detected mainly associated with starbursts and long duration gamma-ray bursts (GRB).

For the evolution and explosion of very massive population III (or primordial) stars the results of theoretical models suggest that these stars explode as giant–HyN with energies of 10^{53} erg (Heger et al. 2002; Heger & Woosley 2002; Nomoto et al. 2004). This giant–HyN with energies up to 100 times that of an ordinary core collapse SN could be also an explanation for the origin of superbubbles. Heiles (1979) already suggested that this single giant SN or HyN scenario need to be considered (together with the multiple SN explosions model) in order to study the origin of supergiant bubbles. Thus, this single/few giant–HyN scenario is a probable and interesting option to consider for the origin of the expanding supershells, detected in BAL + IR + Fe II QSOs.

For the origin of BAL systems in QSOs/AGNs, in the composite starburst+AGN with OF/GW scenario, different theoretical models were proposed. In particular: (i) in SN ejecta (very close to AGN with galactic wind), which are shock heated when a fast forward shock moves out into the ISM (with a velocity roughly equal to the ejecta) and a reverse shock accelerates back and moves towards the explosion centre; the blue absorption lines arise since SN debris moving toward the central source are slowed down much more rapidly -by the AGN wind- than is material moving away (Dyson et al. 1992; Perry & Dyson 1992; Perry 1992); and (ii) for IR dusty QSOs with OF/GW, in the outflowing gas + dust material the presence of discrete trails of debris

(shed by individual mass-loss stars) could produce the BAL features (Scoville & Norman 1995; Scoville 1992).

These two models studied physical processes for small galactic-scale. Now we consider the alternative of expanding supergiant shell, as the origin of BAL systems (which is similar to the SN ejecta model but at large scale). This alternative was already argued in order to explain the BAL system in the IR + Fe II QSO IRAS 07598+6508 (Lípari 1994; see also Bond et al. 2001; Guillemin & Bergeron 1997).

Specifically, important theoretical results were obtained by Tenorio-Tagle et al. (1999), who studied a scenario based on the hydrodynamics of superbubbles/galactic wind powered by massive starbursts that account for different type of BAL systems detected in star-forming galaxies (Kunth et al. 1998; Mas-Hesse et al. 2003). These type of starburst models could explain mainly the BALs associated with low velocity OF. For IR + Fe II QSOs the OF processes show extreme velocity and very explosive events (probably associated with the interaction between the AGN and the evolution of massive star formation process in the accretion nuclear regions; proposed by Collin & Zahn 1999). In this last scenario the presence of hypernova explosions are expected.

Therefore, in this supergiant shell scenario the physical processes could be similar to those studied by Tenorio-Tagle et al. (1999), but the deposition of kinetic energy in the ISM by extreme SBs (with HyN) is larger than in standard SBs.

On the other hand, for IRAS 04505–2958, the UV spectra clearly show a BAL system at C IVλ1549 emission line (see Lípari et al. 2005a). For this BAL system was measured $\lambda = 1978.5$ Å, corresponding to an ejection velocity of –1645 km s^{-1}. This ejection velocity is –within the errors– the same that the previous value of OF obtained using the offset method: –1700 km s^{-1}! (by Lípari et al. 2004d). The offset method used for the study of OF–candidates IR QSOs (including IRAS 04505–2958) means that the Hβ broad line component is blushifted in relation to the narrow one. Thus this result obtained for IRAS 04505–2958 suggests that the optical low ionization BLR and the BAL could be originated in the same OF process or supershell.

Different works even proposed that the broad line *emission* region could be associated with OF processes. In particular, these works suggest that the BLRs are located in the OF of: accretion disks, the ejecta of SN remnants, shocked clouds (by a nuclear galactic wind) around SN remnants, extended stellar envelopes, etc (see for references/review Sulentic, Marziani, & Dultzin–Hacyan 2000; Terlevich et al. 1992; Dyson, Perry & Williams 1992; Scoville & Norman 1988). Thus an interesting questions is: could an explosive event generate a very unusual spectrum similar to that detected in the nuclear region of AGNs like Mrk 231?. Figure 14 in Lípari et al. (2005a) shows the superposition of the spectrum of the unusual radio SN type II–L 1979c (observed in 1979 June 26.18; Branch et al. 1981). Only using colours we can distinguish each spectrum, since they are almost identical. A more constant OF (than a single and standard SN) could explain even the optical spectrum of some BLR.

In particular, Lipari et al. (2005a) suggested that Fe II emission could originate in warm regions obscured from direct ionizing UV photons, the obscuring material being in the form of expanding shells. The giant explosive events occurring from the evolution of very massive stars would produce shock-heated material. This suggestion is in good agreement with our recent finding, for the BAL + IR + Fe II QSOs IRAS 07598+6508, that the properties of the BLR are consistent mainly with collisional rather than radiative models (Veron et al. 2006).

Therefore, following the results discussed in the last two sections, in the composite SB + AGN scenario even the emission of the BLRs could be associated with one or a combination of the following physical processes: (i) single or few HyN explosions with OF shells, (ii) multiple cSNRs, (iii) standard BLR of clouds moving around the AGNs, and (iv) in the OF (or in the surface) of AGN accretion disks.

7 PREDICTIONS OF THE EVOLUTIVE AND COMPOSITE MODEL FOR AGNS.

Based in the conclusions and results from the previous sections we can now proceed to describe in a semi-quantitative way the evolution of a nuclear cluster and BH. The evolution of the properties of the BLR with time is one of decreasing Fe abundance and increasing mass of the SMBH. In particular:

- **The NLR size, emission line width and profiles.**

The NLR would evolve from a very compact one with the size of few times the size of the cluster to a fully developed NLR of kiloparsec size. The increase in size of the NLR should be reflected in some systematic change in the line width and profiles of the forbidden lines with time. Simple models of wind driven bubbles predict that early in the evolution of the bubble the velocities of the shocked gas will be close to about half of the average wind velocity while at the end of the evolution the gas motions will be closer to those of the ISM. The NLR line profiles should reflect this change in same degree. Although no precise prediction can be made without detailed models, from a qualitative point of view it is still possible to predict that the broad [O III] profiles associated with the relatively strong Fe II emitters should have shell-like profiles while narrower [O III] profiles should be either flat top (disk-like) or Gaussian (spherical-like)

- **The BLR line width.**

The line width of the BLR should evolve with time as the SMBH increases its mass. Thus a relation between line width of the BLR and strength of Fe II is expected. The relation is in the sense that young objects with very strong Fe II emission will have narrower lines in the BLR while older objects with weak or absent Fe II emission will have fully developed broad permitted lines.

- **The X ray spectrum.**

As the ejecta velocity of the cSNR increases with the age of the cluster, shock velocities are also expected to increase, consequently the shock temperature will increase with cluster age. Simultaneously the Fe II/ Hβ ratio will decrease. Relatively old clusters (with age > 20 Myr) will have very weak Fe II emission and hard X ray spectrum while young clusters will emit strong Fe II and have a softer X ray spectrum.

- **The Red Supergiant phase.**

Stellar evolution models predict that the contribution by RSG to the total emitted spectrum of a metal rich stellar cluster will be maximum at ages $8 < t < 20$ Myr . During

this time some stellar features like the IR CaII triplet at $\sim$ 8500$\AA$ should be particularly strong (Terlevich et al. 1991).

8 BAL + IR + FE II PHENOMENA AND THE EVOLUTIVE AND COMPOSITE MODEL.

• **The Broad Absorption Line systems:**
Strong evidence of the composite nature of BAL systems were found in Mrk 231. Thus, the large galactic-scale outflow with superbubbles in BAL + IR + Fe II QSOs (Lípari et al. 2003, 2005a,c,d) is an interesting alternative for the origin of "some" BAL systems in these IR objects. We already noted that Tenorio-Tagle et al. (1999) studied a scenario based on the hydrodynamics of superbubbles/galactic wind powered by massive starbursts that account for different type of BAL systems detected in star-forming galaxies, with low velocity OF. We suggest that for IR + Fe II QSOs the physical processes could be similar to those studied by Tenorio-Tagle et al. (1999), but the deposition of kinetic energy (in the ISM) by extreme SBs is larger than in standard SB.

The effects of the orientation of the line of sight and dust obscuration could play a secondary role, in the observation of BAL systems. Specifically, the BALs could be more easy to detect (in young QSOs) if the winds are observed edge on.

It is important to note that the supergiant shells/arcs scenario (for the origin of BALs) is in agreement with an interesting observational result: the detection of a high fraction of supergiant shells, arcs and rings, in low-ionization BAL + IR + Fe II QSOs (Lipari et al. 2003).

• **The strong IR continuum emission:**
An interesting prediction of the starburst + AGN model is related with luminous IR galaxies (Sanders & Mirabel 1996) as the progenitors of QSOs. As discussed by Terlevich & Melnick (1988), the early HII phase (of the SB) are associated with large amount of dust. This is due not only to the dust present in any star formation region but also to the large amount of dust synthesized by the most massive stars during the η-Carinae phase before becoming WR stars. During this phase up to 1 M$\odot$ of dust per evolved massive star may be injected into the core ISM, enshrouding most of the massive stars. The emitted luminosity will be therefore, dominated by the far infra-red (FIR) luminosity and these systems will presumably be present in large numbers in the IRAS sample of galaxies with Starburst and Seyfert 2 nuclei.

The HII and Seyfert 2 phase that precedes the QSO phase, lasts 8×10^6 years, or about 1/10 of the duration of the QSO phase. During this early phase, the cluster luminosity is at its maximum, and on average, about 4 times higher than during the QSO phase. The QSO progenitor should therefore be a luminous and short lived (short compared with the QSO life-time) FIR source. Comparative studies of the luminosity function of IRAS galaxies and QSOs should show if IRAS galaxies are, at a given epoch, about 4 times more luminous in bolometric units and about 10 times less frequent than QSO. This simple prediction applies only to the case of a coeval population; systems where the star formation time scale is longer will show a mixture of all four phases at all times and will therefore probably look like a QSO for most of their bright phase.

• **The strong Fe II intensity and the [O III]/Hβ vs. Fe II/Hβ anti correlation:**
Because the Fe abundance of the ISM in the nuclear region decreases systematically with time from several times over solar to solar value, the Fe II intensity is expected also to decrease with time.

The first few generations of massive type II SN will clear the dust from the inner parts of the cluster. The combined action of many X ray/UV flashes of the cSNR, reaching each of them 10^{10} L$\odot$ and lasting about one year would evaporate the dust in the central regions of the cluster. As SN activity proceeds, therefore the flux of hard X ray and UV radiation reaching galactic ISM at large distances should increase with time. This is a necessary condition to produce luminous forbidden lines. The model predicts that the NLR will develop as the same time as the Fe II intensity decreases.

9 COMPARISON BETWEEN THE OBSERVATIONS AND THE MODEL.

To assess the reality of the relations and search for new ones, we have compiled from the literature measurements of Fe IIλ4570 / Hβ , FWHM Hβ , [O III]/ Hβ ,IR luminosity, X ray spectral slope for nuclei with measured Fe IIλ4570 / Hβ. Our data base of Fe II AGNs and QSOs emitters is based mainly in the data published by Bososon & Green (1992); Joly (1991); Wills et al. (1985, 1992); Lipari et al. (2005a, 2004a,b,c,d; 1993, 1991); Zheng et al. (2002), and others. Although the sample is non-homogeneous with respect to the quality of the data and measurement procedures it is nevertheless useful for statistical purposes. For example several correlations reported in the literature can be illustrated with this sample (see Figure 3).

A correlation not discussed in the literature is that of [O III] FWHM and the relative intensity of Fe II (Fig. 2b). We have explored this relation and found that the FWHM of [O III] is smaller in weak Fe II emitters (this behaviour is the opposite of that of the FWHM of Hβ). This is consistent with the finding of Boroson & Green (1992) that the peak [O III] is better correlated with the relative intensity of Fe II than the [O III] relative intensity.

Because of differential extinction between the receding and approaching sides of the expanding NLR it is expected that the blue wing of the [O III] line should be stronger than the red wing. This should introduce an asymmetry in objects with broad and relatively faint [O III].

The model predicts that the IR CaII triplet in emission should reach maximum brightness at ages between 10 and 20 Myr. At the same time the triplet in absorption should also reach maximum intensity. Because of the large intensity of the IR CaII triplet in emission it is in principle difficult to detect an underlying absorption where each line has at most 10Å equivalent width. It was very surprising for us when searching the literature a posteriory that the stellar absorptions have been indeed detected in many of the strong Fe II and CaII emitters (Persson 1988; van Groningen 1993).

Persson (1988) detected CaII triplet absorption in two of his strong CaII emitters (Mrk 42, Mrk 6). Because the ratio of absorption line intensities is 1:9:5 while the emission lines are on average about equal, the most affected emission will be the 8542 Å line while the least will be the 8498Å line.

Mrk 42 shows inversion in the profiles that can be attributed to narrow stellar absorption. The case of Mrk 6 is simpler due to the fact that the BLR is shifted with to the blue with respect to both the NLR and the stellar absorptions. Evidence for absorption can be found in other of Persson strong Fe II emitters like Mrk 1239, Mrk 766 and most noticeably for its similarity with Mrk 42 in Mrk 684. This is better seen in the Persson high dispersion data (Persson fig 4) where the left side shows the spectra of Mrk 42, Mrk 1239 and Mrk 6 all of them with clear indication that 8542Å is the stronger of the absorption features detected.

van Groningen (1993) in an analysis of the spectra of three Seyfert 1 galaxies with strong CaII emission detected strong IR CaII triplet absorption in Mk231. On the other two nuclei he observed that the FWHM of the CaII lines is larger than the rest of the broad lines while the width at zero intensity is the same. In the analysis of the excess FWHM of the CaII lines van Gronningen did not considered the influence of the underlying stellar absorption that, as pointed by Persson (1988; see appendix) any study of IR CaII line profiles should pay attention to the stellar absorption effects, as it is clear that the deduced FWHM values will be overestimated unless profiles are first corrected for absorption.

The simultaneous occurence of strong IR CaII broad emission and strong IR CaII stellar absorption, is a very important prediction of the model that deserves to be further investigated. It provides strong and independent evidence that the sequence of Fe II strength is a sequence in stellar age and not in aspect ratio. Further independent information may be obtained from studies of the 2.3μ CO index that as the IR CaII triplet is very strong in RSG.

10 CONCLUSIONS.

The following relations are not explained inside current Unified models of AGN (where differences between types are due entirely to orientation effects): (i) Strong BAL + Fe II QSOs tend to be also strong IR sources. (ii) FWHM of Hβ vs. Fe II/Hβ anti-correlated. Hβ is narrower in strong Fe II emitters. (iii) X ray spectral index vs. Fe II/Hβ anti-correlated. The X ray spectrum slope is steeper in strong Fe II emitters. (iv) [O III]/Hβ vs. Fe II/Hβ anti-correlated. [O III] is weaker in AGN with strong Fe II.

In this paper we have explored an evolutionary and composite Unified scenario involving super massive black hole and starburst with outflow, that seems capable of explaining most of the observational properties of AGNs. Our suggestion is explored inside the expectations of the Starburst model close associated with the AGN.

In particular, the prominence of BAL + Fe II emission in quasars with strong infrared to optical luminosity ratio is consistent with the assumptions of a composite heating source linked to violent SB and AGN processes (Lípari et al. 1994, 2003, 2004a,b,c,d, 2005a).

The Fe II emission could be associated with rapidly cooling supernovae remnants and/or expanding shells occurring in the central regions of galaxies undergoing intense starburst activity (Terlevich et al. 1992; Lipari et al. 2005a; Veron et al. 2006). We suggest that the observed properties of AGN with Fe II emission can be understood as an evolutionary sequence where the observed differences between strong and weak Fe II emitters and the observed correlations with Fe II relative intensity, are related to evolutionary changes in the cSNR and SN activity and the development of the NLR in a nuclear starburst.

Theoretical models of type II SN nucleosynthesis indicate that type II SN with masses larger than 12 M$\odot$ synthesise large amounts of iron while stars of lower mass produce little or no iron. Photoionization models of cSNR with ejecta abundances corresponding to the theoretical predictions indicate that cSNR associated with massive progenitors typical of young Starbursts (age about 10 Myr) will have very strong Fe II emission lines. The BLR of AGN with strong Fe II emission could be massive cSNR corresponding to relatively young (8 Myr < age < 20 Myr) Starbursts with during massive ($\sim 25 > M >\sim 12$ M$\odot$) type II SN activity. In these relatively young and dusty starburst the NLR is small and confined to the proximity of the starburst therefore generating only weak forbidden lines. The large ejected masses in these massive type II SN will also produce cSNR with relatively lower ejecta velocity and therefore lower velocity shocks, narrower permitted emission lines and softer X ray spectrum than those of low mass cSNR ($\sim 10 > M >\sim 7$ M$\odot$) typical of older starburst (40 Myr < age < 60 Myr) . These older starbursts have low mass SN progenitors that synthesise little or no Iron at all, and eject a smaller mass. Thus, older starburst will have cSNR with weak Fe II lines, high velocity shocks, broader emission lines and harder X ray spectrum. Due to the thermal pressure of the SN activity the NLR expands reaching maximum development only in older starburst. Only these older starburst will show bright forbidden lines and large, i.e. fully developed NLR.

We find good agreement between the predictions of the model and the observed correlations between Fe II intensity, BLR line width, [O III] intensity and X ray spectral slope of AGN. Additionally, predictions relating the Fe II intensity to the FWHM and asymmetry parameter of the [O III] lines are corroborated.

Radio loud systems may be associated with the later stages of evolution. We also argue that the fact that radio loud AGN double or extended morphology tend to show no Fe II and very broad permitted lines while core dominated AGN tend to show Fe II in emission and narrow permitted lines suggest also an evolutionary sequence. Furthermore, since the timescale for the development of megapersec size radio sources may be similar to the lifetime of the AGN (Fanti et al. 1995), the size of radio sources should not depend solely on projection effects.

We propose a check for this evolutionary model based in the fact that the epoch of Fe rich ejecta (8 Myr < age < 20 Myr) coincides with the peak of Red Supergiant activity (8 Myr < age < 15 Myr) in metal rich stellar populations. Thus the underlying stellar continuum of strong Fe II emitters should have stronger IR CaII triplet absorption lines than that of weak Fe II emitters. Because of the strong age dependence of the RSG activity, a statistical study of the strength of the IR CaII triplet absorption as a function of Fe II intensity can provide a powerful test of our model.

In Summary, in the evolutive and composite unification scenario the following main ideas were proposed (or confirmed): (i) BAL QSOs are young systems with composite OF. (ii) The Fe II intensity provides an age indicator for

BLR AGNs. (iii) BLR emission line FWHM changes with age. (iv) X ray slope changes with age. (v) [O III] intensity and FWHM changes with age. (vi) The strong IR continuum emission is associated with the composite nuclear nature. (vii) The Sy1/Sy2 and BLRG/NLRG segregation is mainly due to orientation/obscuration by toroid.

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Figure 1. IR colour–colour diagram for IR mergers/QSOs with galactic winds (from Table 1 of Lípari et al. 2005a) and for standard QSOs (from the PG sample; Boroson & Green 1992). The black dashed line depicts a probable evolutive path: from IR mergers with low velocity OF to IR QSOs with extreme velocity OF. In the transition area between the black body and power law regions we found a clear sequence of BAL + IR + Fe II QSOs (starting from Mrk 231 and IRAS 07598+6508, which are located very close to the black body region).

Figure 2. Plot of the ratio Fe IIλ4570 / Hβ vs. Velocity (offset) OF, for IR QSOs. The data were obtained from Lipari et al. (2004d): Table 8.

Figure 3. Fig. 3a. the relation between the ratio of the equivalent widths (EW) of Fe IIλ4570 / Hβ vs. Peak of [O III]. The open and fill squares are bright and faint QSOs, respectively. Fig. 3b. the relation between the ratio of the equivalent widths of Fe IIλ4570 / Hβ vs. FWHM of [O III]. The dashed lines show linear fits of the two set of data.

Figure 3. Fig. 3c. the relation between the magnitud M_V vs. FWHM of [O III]. The open and fill squares are strong and weak Fe II emitters, respectively. Fig. 2d. the relation between the Fe IIλ4570 emission vs. FWHM of [O III]. The dashed lines show linear fits of the different set of data.